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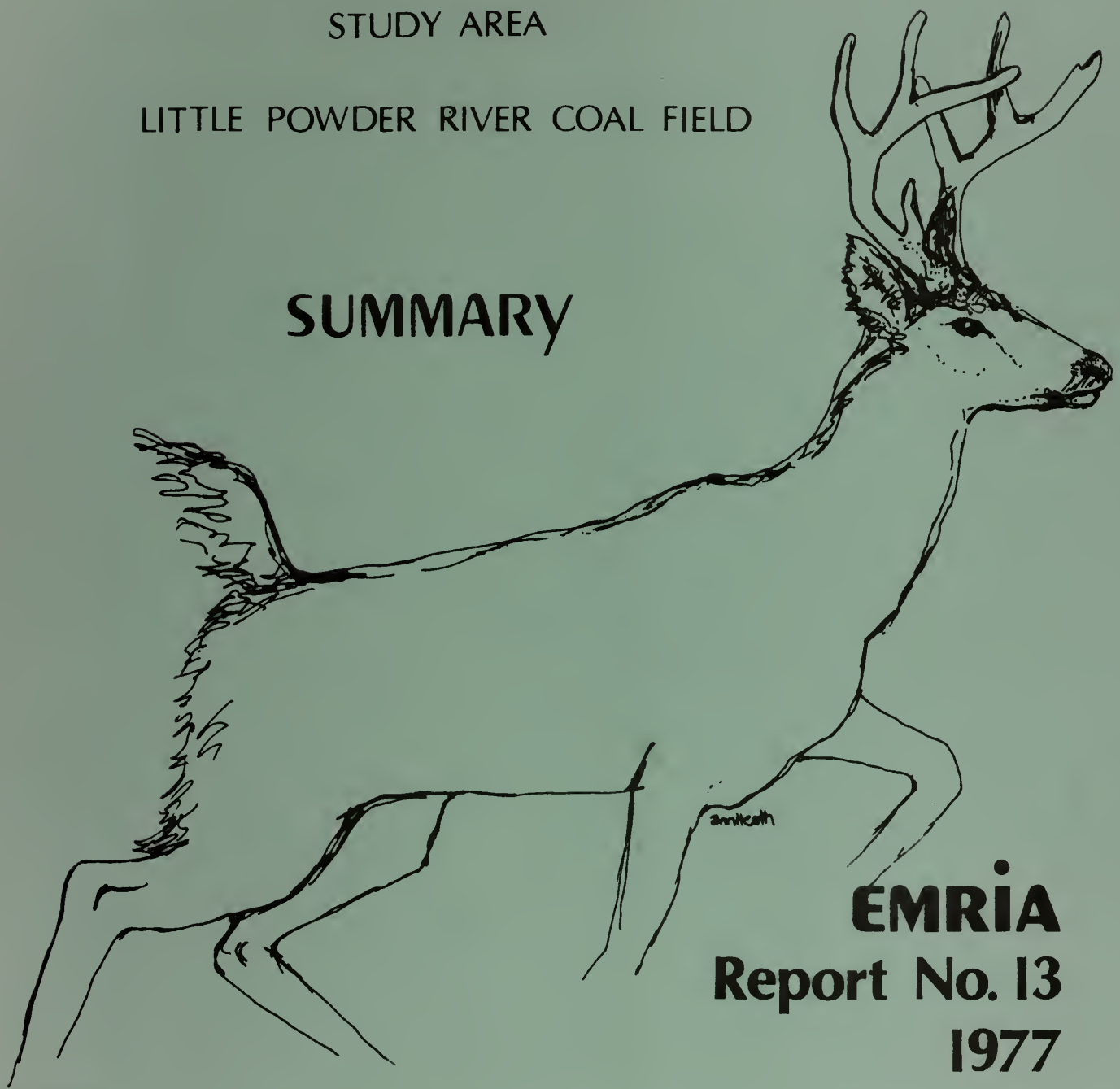
Resource and Potential Reclamation Evaluation

White Tail Butte

STUDY AREA

LITTLE POWDER RIVER COAL FIELD

SUMMARY



EMRIA
Report No. 13
1977

United States Department of the Interior
Bureau of Land Management
Water & Power Resources Service
Geological Survey

BUREAU OF LAND MANAGEMENT
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EMRIA
(Energy Mineral Rehabilitation Inventory and Analysis)

EMRIA is a coordinated approach to the collection, analysis, and interpretation of overburden (soil and bedrock), hydrology, vegetation, and energy resource data. The main objective of the effort is to assure adequate baseline data for choosing reclamation goals and establishment of lease stipulations through site-specific preplanning for surface mining and reclamation.

These reports are prepared through the efforts of the Department of the Interior, principally by the Bureau of Land Management, Water and Power Resources Service, and Geological Survey. Assistance is also provided by other Federal and State agencies.

Reports under this effort are:

EMRIA Report	Location
1	Otter Creek, Montana
2	Hanna Basin, Wyoming
3	Taylor Creek, Colorado
4	Alton, Utah
5	Bisti West, New Mexico
6	Foidel Creek, Colorado
7	Red Rim, Wyoming
8	Bear Creek, Montana
9	Horse Nose Butte, North Dakota
10	Beulah Trench, North Dakota
11	Pumpkin Creek, Montana
12	Hanging Woman, Montana
13	White Tail Butte, Wyoming

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INTRODUCTION

Recent energy shortages have forced our society to seek new domestic sources. Attention has focused on the immense quantities of low sulfur coal that lie within the Rocky Mountain and Northern Great Plains regions. It is the responsibility of the Department of the Interior and principally the Bureau of Land Management to assist in meeting these energy demands and at the same time, provide sound reclamation guidelines so that the disturbed lands are restored to an acceptable condition.

PURPOSE

The purpose of this report is to provide information for establishing reclamation objectives and lease requirements. Detailed data is given on geology, coal resources, overburden (soil and bedrock), greenhouse, vegetation, sedimentation, and hydrology. Less detailed information is provided on climate, physiography, wildlife, cultural resources, recreation and visual management.

LOCATION

The White Tail Butte Study Area is located in Campbell County, Wyoming, approximately 35 miles north of Gillette. The area includes about 2,300 acres in all or parts of sections 30, 31, and 32, T. 56 N., R. 72 W., and sections 24 and 25, T. 56 N., R. 73 W. (see Plates 1, 2, and 3 and Photograph 1).

CLIMATE

The White Tail Butte Study Area has a continental-type climate characterized by cold winters, warm summers, and large variations in seasonal precipitation.

The mountains along the Continental Divide west of the study area cause air masses to rise and precipitate their moisture. As a result, a rain shadow is created over eastern Wyoming. The average annual precipitation recorded at stations within a 40-mile radius of the study area ranges from 12.5 to 19.1 inches. The average annual rainfall in the study area is approximately 16.3 inches. About 72 percent of the annual precipitation falls between April and September. The principal growing season, May to July, receives about 38 percent of the annual rainfall.

The average annual temperature (based on average daily temperatures) in the study area is about 43.2°F. Maximum and minimum temperatures which have been recorded in the area are 107.6°F. and -43.6°F., respectively.

The frost-free period is approximately 115 days, starting in late May and ending in mid-September. The growing season for hardy crops and native grasses is about 136 days.

Considerable sunshine can be expected in all seasons. July has the largest number of days with sunshine. May and June are typically the cloudiest months. Thunderstorms and occasional destructive hailstorms are most common in July and August.

In general, the climate of the White Tail Butte Study Area appears favorable for revegetation of surface-mined land with adapted plant species. The pre-growing season moisture of 2.1 inches is stored in the root zone and, when combined with the principal growing season moisture of 7.2 inches, promotes rapid growth of spring planted grasses.

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Climatic factors that may adversely affect revegetation efforts in this study include: (1) below normal or uneven distribution of precipitation, especially during the growing season, (2) thunderstorms or strong winds that cause erosion, (3) late spring freezes, and (4) depletion of soil moisture by wind.

PHYSIOGRAPHY

The White Tail Butte Study Area lies in the unglaciated portion of the Great Plains physiographic province. The topography is characterized by gently rolling uplands dominated by isolated knobs and buttes.

Maximum relief is about 350 feet, ranging from an elevation of approximately 4,340 feet on White Tail Butte, near the center of the area, to an elevation of about 3,990 feet at the north edge of the area.

Dendritic drainages in the area empty northward into Elk Creek and southward into White Tail Creek. Both creeks are intermittent tributaries of the Little Powder River.

GEOLOGY

The White Tail Butte Study Area is in the eastern part of the Powder River Basin. This deep sedimentary basin is about 225 miles long and 90 miles wide. It extends from the Yellowstone River in Montana to the North Platte River in Wyoming and from the Black Hills of South Dakota to the Bighorn Mountains of Wyoming.

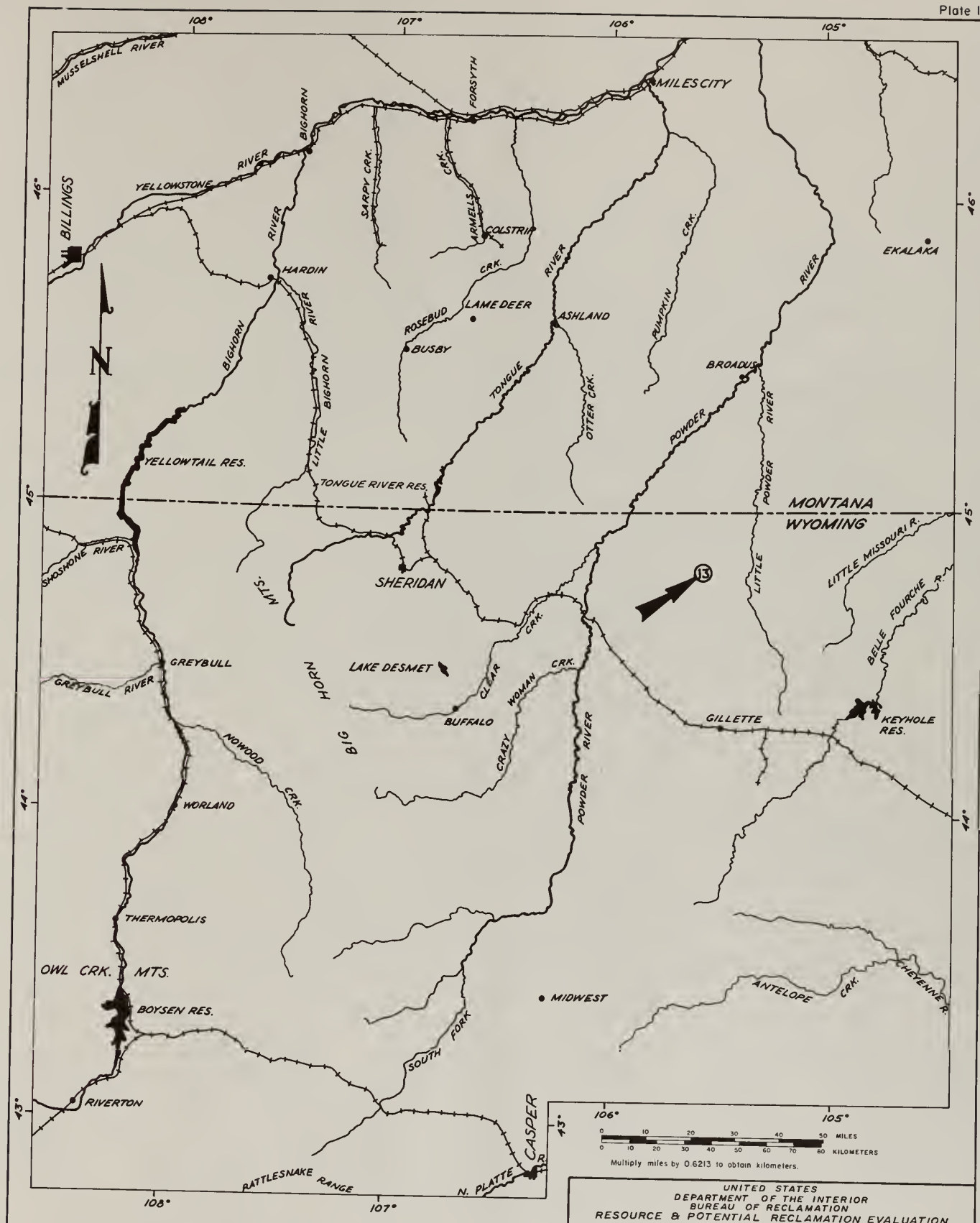
Sedimentary strata exposed in the study area are the Fort Union Formation of Paleocene Age and the Wasatch Formation of Eocene Age. Alluvial deposits of Holocene Age mantle valley floors of the major tributaries.

Twelve persistent coalbeds crop out or were penetrated by drilling in the study area. Three coalbeds of economic significance occur within 200 feet of the surface. They are the Anderson, Dietz, and Canyon coalbeds. The Anderson averages about 34.3 feet thick. The Dietz splits in the area and ranges from over 28 feet thick in Drill Hole 76-102 to a combined thickness of 18 feet in the two benches in the western part of the area. The Canyon coalbed averages 21.6 feet thick.

Engineering property tests conducted on bedrock samples similar to the materials in the White Tail Butte Study Area have revealed that shear strengths are low, especially in a saturated condition. Slides can easily develop adjacent to high walls in surface mines, primarily along beds of weak, plastic, carbonaceous shales. Saturated alluvial deposits and uncemented siltstones and fine-grained sandstones will readily erode and flow into excavations.

Excavation slopes will vary between minesites and be dependent on exposure time, moisture conditions, material types, and depth of cut. Adequate drainage will have to be maintained to relieve pore water pressure in the overburden, and excavation below the water table will be limited until the material is drained.

Studies of similar material at other EMRIA sites indicate that disturbed overburden should have slopes not greater than 4 to 1, with berms 50 to 100 feet wide designed on the slope surface.



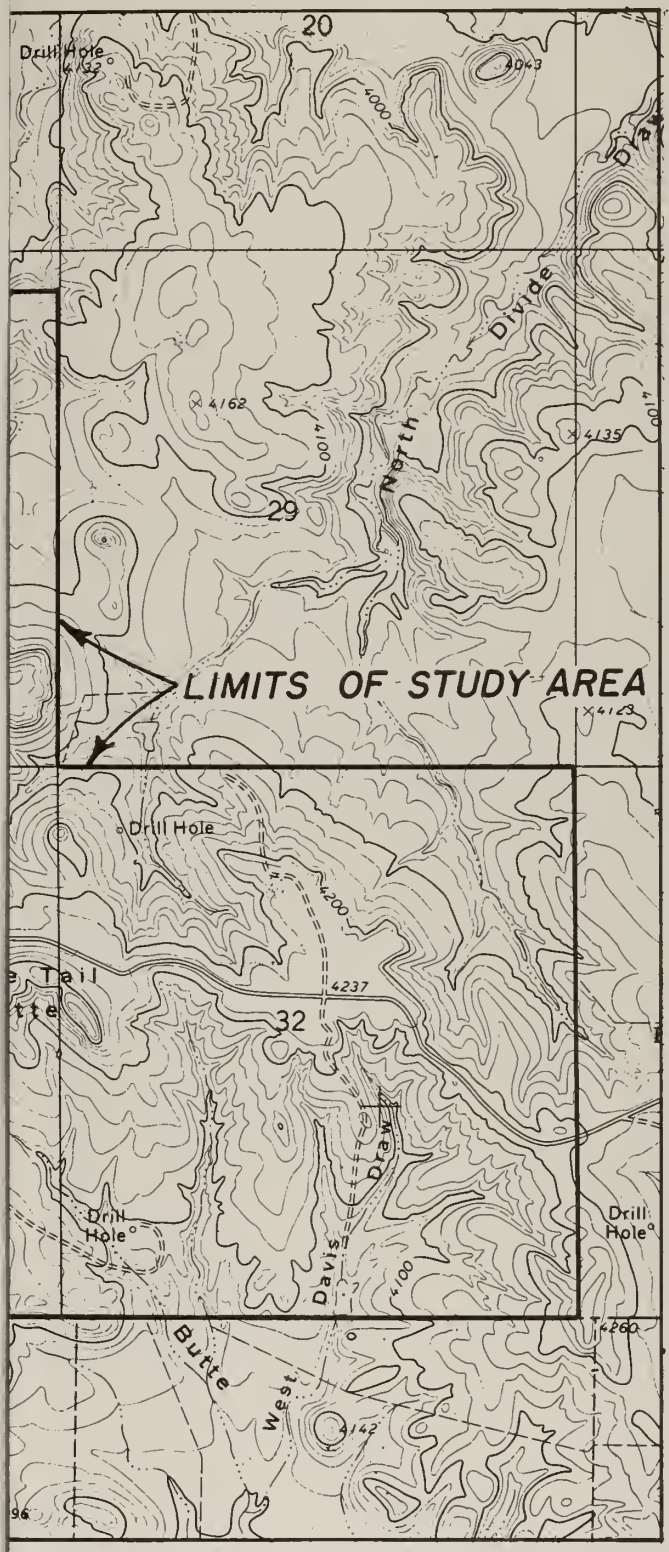
(13) WHITE TAIL BUTTE STUDY AREA-EMRIA NO. 13

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
RESOURCE & POTENTIAL RECLAMATION EVALUATION

EMRIA STUDY AREA
MONTANA—WYOMING

GENERAL LOCATION MAP

DESIGNED	SUBMITTED
DRAWN G. TAUCHER	RECOMMENDED
CHECKED	APPROVED
BILLINGS, MONTANA MARCH 1976	1305-600-35



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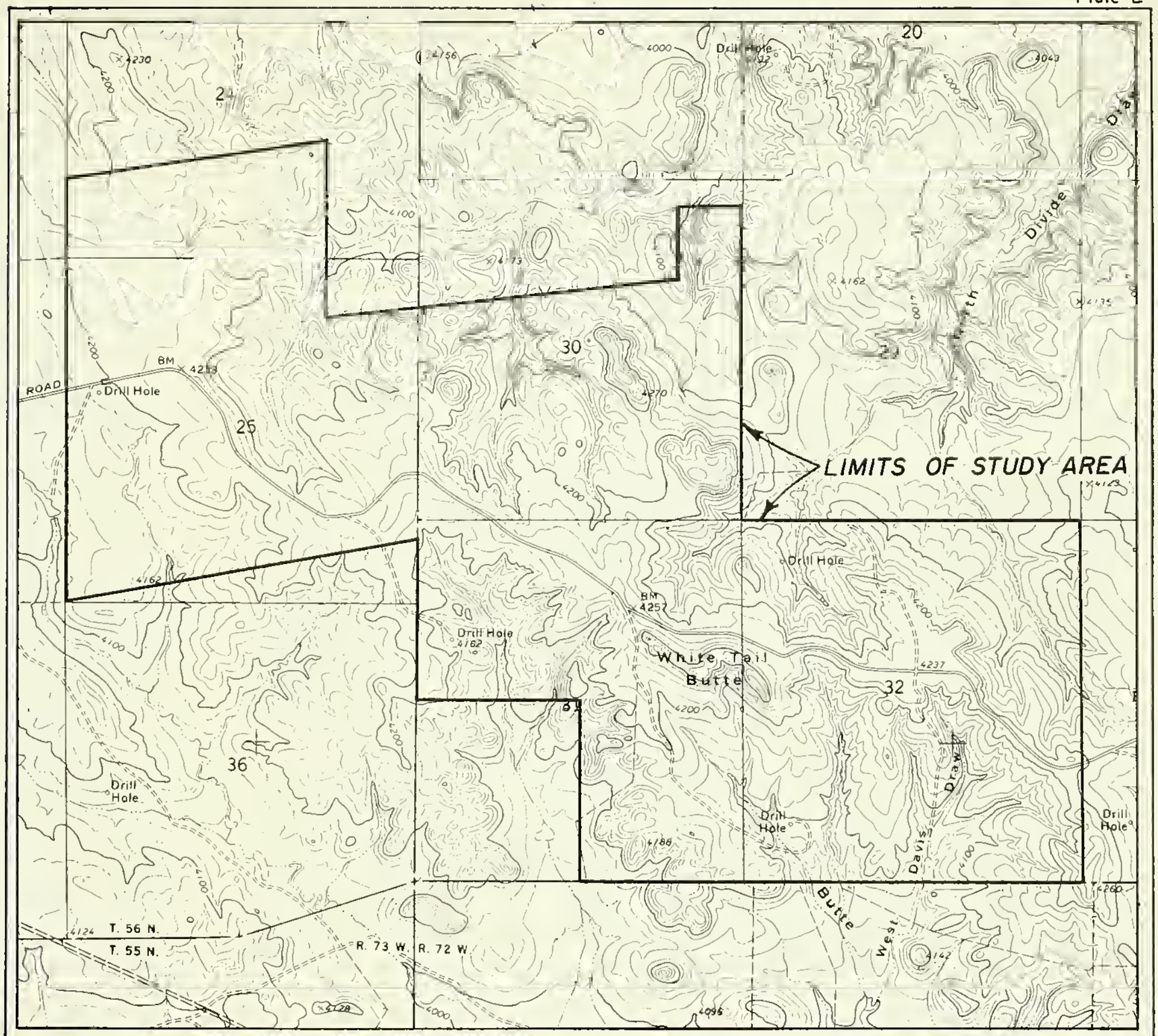
RESOURCE & POTENTIAL
RECLAMATION EVALUATION

WHITE TAIL BUTTE STUDY AREA
LITTLE POWDER RIVER COALFIELD
WYOMING

TOPOGRAPHY



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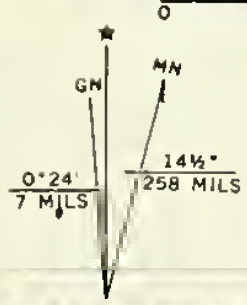
0 300 600 900 1200 1500 METERS

CONTOUR INTERVAL 20 FEET
Multiply feet by 0.3048 to obtain meters



UTM GRID AND 1971 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

QUADRANGLE LOCATION

PORTION OF USGS WHITE TAIL BUTTE QUADRANGLE

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WHITE TAIL BUTTE STUDY AREA
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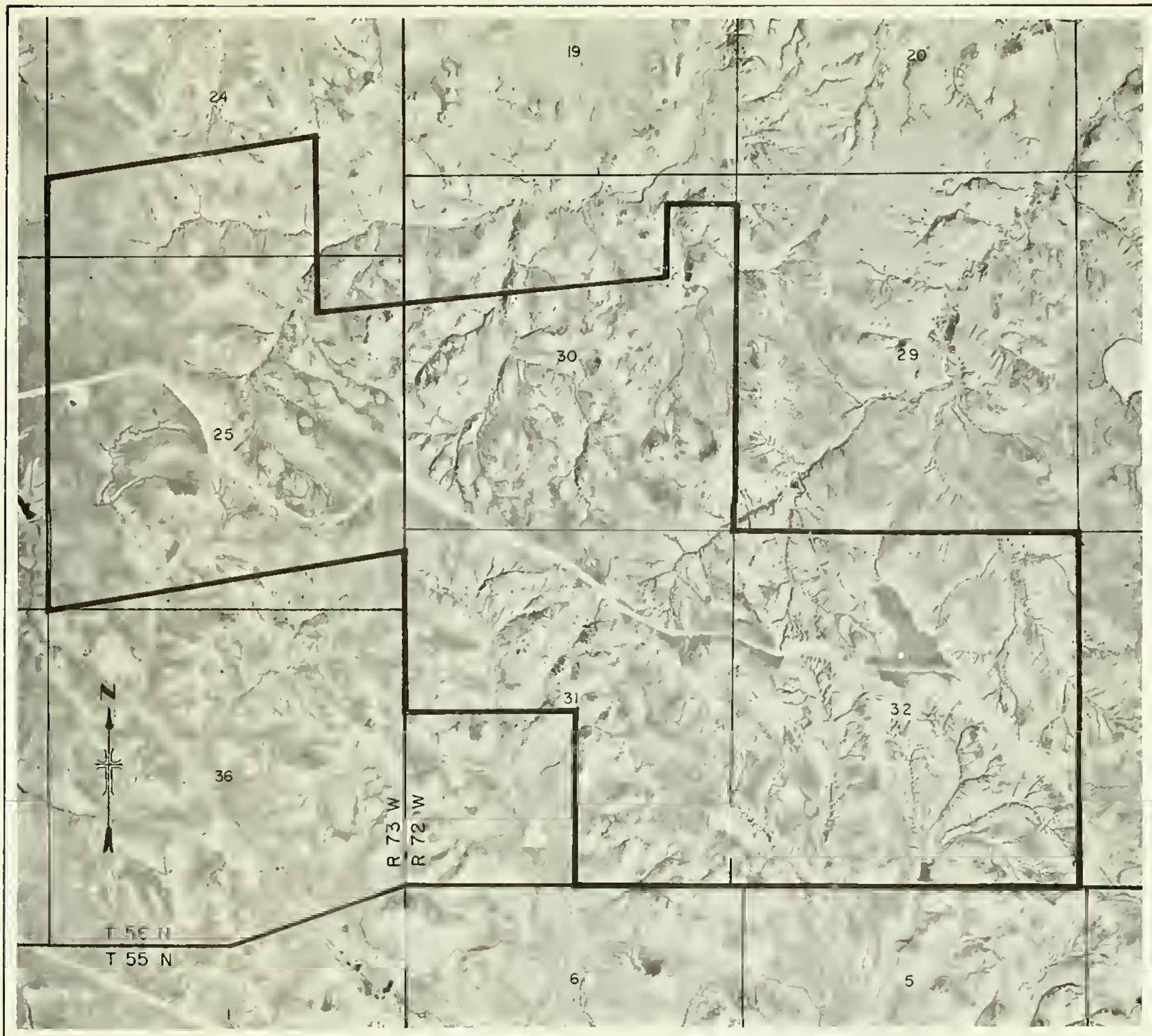
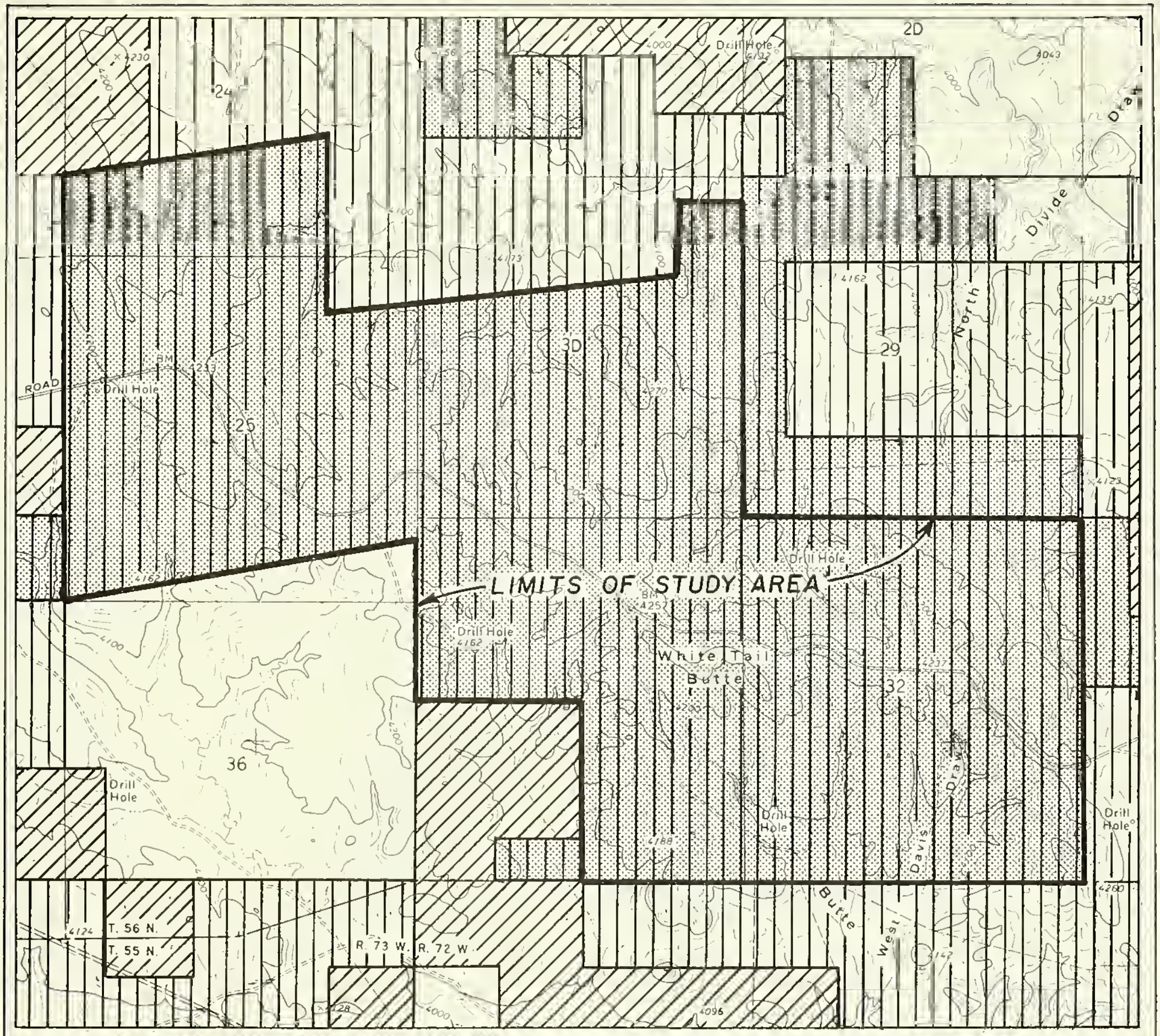


Photograph 1 - WHITE TAIL BUTTE STUDY AREA - LITTLE POWDER RIVER COALFIELD, WYOMING - Aerial view of study area (outlined by heavy line)



MINERALS OWNED BY FEDERAL GOVERNMENT

All Minerals

Coal Only

No Federal Minerals

LAND OWNED BY FEDERAL GOVERNMENT

Multiply feet by 0.3048 to obtain meters

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RECLAMATION EVALUATION

WHITE TAIL BUTTE STUDY AREA
LITTLE POWDER RIVER COALFIELD
WYOMING

MINERAL & LAND STATUS MAP

Volume changes in the overburden will occur with disturbance. An increase in volume of about 25 to 30 percent should be expected. In some cases the surface of the replaced overburden will be higher after mining.

Three types of landscape instability may occur on reclaimed land in the White Tail Butte Study Area. These are: (1) area-wide settling, (2) localized collapse, and (3) piping. Each form of instability is affected by certain variables in the postmining landscape. These variables include the physical and chemical characteristics of the overburden, methods and equipment used in spoil contouring operations, and the season when these activities occur.

Settlement will occur for years after the area is reclaimed. Only structures designed for unstable foundation conditions should be placed on the fill. Drainage channels in the spoil may require periodic maintenance to prevent ponding in settled areas.

A study of the seismic history of the region indicates that minor damage could result to structures from earthquake shocks.

COAL RESOURCES

The White Tail Butte Study Area is located in the Little Powder River Coalfield. Three coalbeds are economically significant. They are part of the Tongue River Member of the Fort Union Formation of Paleocene Age. These beds generally lie within 200 feet of the surface and are, in descending order, the Anderson, Dietz, and Canyon Coalbeds.

Coalbeds in the study area were evaluated by 8 core holes ranging from 275 to 785.5 feet deep. Total measured and indicated coal resources for the Anderson, Dietz, and Canyon Coalbeds that lie within 200 feet of the surface are:

Anderson Coalbed	94,464,000 short tons
Dietz Coalbed	35,185,000 short tons
Canyon Coalbed	24,775,000 short tons

A total of 66 coal samples from the three coalbeds in the study area were tested. The heat of combustion (as received basis) ranged from 6,778 Btu/lb to 7,617 Btu/lb. The ash content (as received basis) averaged about 7.03 percent. The sulfur content (as received basis) averaged about 0.49 percent. The apparent rank of the samples ranged from Lignite 'A' to Subbituminous 'C'.

OVERBURDEN - SOIL AND BEDROCK

PRINCIPAL SOIL BODIES

Soils of the White Tail Butte Study Area may be placed in two major categories based on parent material. They are: (1) residual soils, and (2) colluvial/alluvial soils. Residual soils occupy ridges, tabular divides, footslopes, and steeply-sloping semibadlands; the colluvial/alluvial soils occur primarily on local alluvial terraces, along natural drainages, and on colluvial fans and footslopes. Overall, residual soils represent about 90 percent of the study area,

while colluvial/alluvial soils comprise nearly 10 percent. Native mid- and short-grass vegetation is dominant on both soil types, but scattered big sage and several forb species also occur on the colluvial/alluvial soils.

Residual soils on ridges have stabilized with the climate and erosion is not retarding soil development. Depth varies from 7 inches to over 3 feet, with textures ranging from sandy loam to clay loam. Approximately 2.2 inches of plant-available moisture are retained in these soils. In general, these soils should provide good quality topsoiling material, and stripping conditions appear favorable.

Residual soils on tabular divides comprise nearly 10 percent of the study area. They are moderately developed and have a very permeable clay loam surface layer. However, water movement is restricted by the underlying bedrock. Available water retained for plant use is approximately 2.2 inches per foot. Overall, these soils should provide a good source of material for topsoiling.

On footslopes, residual soils range in depth from 7 inches to over 3.5 feet. The characteristics of these soils closely resemble those of residual soils occupying ridges and tabular divides. These soils should provide fair to good quality topdressing material. However, the ease of stripping this material will be largely dependent on soil depth.

Residual soils forming on steeply-sloping semibadlands are subject to the very active erosional forces of wind and water. Soil is removed almost as rapidly as it is formed. The resulting soil profiles are weakly developed and closely resemble the underlying parent bedrock in their physical and chemical characteristics. Generally, they are a poor source of topsoiling material due to their variability and the difficulty incurred in stripping the available material on steep slopes.

The colluvial/alluvial soils occur on fans and footslopes, along natural drainages, and on local alluvial terraces. Profile development ranges from slight in recently deposited sediments to moderate in soils on footslopes and upland terraces. In general, these soils are moderately permeable, calcareous in the subsoil, and retain about 2.2 inches per foot of plant-available moisture. The soil mantle often extends to depths of over 5 feet. Overall, these soils should provide an abundant source of good quality topsoiling material.

LAND SUITABILITY SURVEY

A detailed land suitability survey was made to determine the suitability of overburden (soil and bedrock) materials for use in revegetating the study area if it is surface-mined. Land suitability specifications were developed specifically for use in this study area. Field and laboratory data were used to evaluate the quantity and quality of materials in the soil mantle and bedrock.

Four land classes, 1, 2, 3, and 6, were established to group land of equal suitability for the specific use of revegetation. Class 1 lands provide the most desirable and plentiful source of easily stripped revegetative material. Land in this class may have surplus suitable material that can be utilized in deficient areas. Class 2 lands have adequate resurfacing material, but of lower quality and more difficult to strip than Class 1 lands. Class 3 lands

are marginally suitable, but can meet the planting media needs for their revegetation. Class 6 lands are deficient in adequate suitable material; therefore, it will be necessary to borrow suitable material from adjacent lands or modify the available material in order to meet the needs for revegetation.

The results of the land suitability survey of the White Tail Butte Study Area expressed as a percentage of the area are as follows: Class 1 - 32; Class 2 - 24; Class 3 - 27; and Class 6 - 17.

OVERBURDEN SUITABILITY

Soil Mantle Suitability

The A and B horizons of most soils in this study area will provide the most suitable material available for topdressing shaped mine spoils. Generally, these horizons are nonsaline, nonsodic, and permeable. Most of the soil organic matter is contained in these horizons. Stripping these horizons separately appears impractical because the A horizon is typically only 2 to 6 inches thick. In A-C soil profiles, the upper portion of the C horizon is often comparable to the B horizon of other soils for use as plant media.

Soluble salts have been leached to a depth of about 2 feet in deep, loamy soils with good permeability. For most soils in this area, this includes the A, B, and part of the C horizons. Soluble salts often remain near the surface in shallow A-C soils, seep areas, and saline-sodic soils.

Local tracts of clay-rich, saline, or saline-sodic soils will require borrowed material from adjacent lands or modification of the available material.

Bedrock Material

Similar criteria were used for the land suitability survey and bedrock core evaluation in the White Tail Butte Study Area. However, different suitability classes were assigned to the core materials. These classes relate primarily to quality of the bedrock materials for use as plant media in revegetation. The suitable class is roughly equivalent to Classes 1 and 2 in the land suitability survey, limited suitability to Class 3, and unsuitable to Class 6.

Overall, 7.1 percent of the bedrock materials overlying the Canyon Coalbed in this study area were determined to be "suitable" for use as plant media; 35.9 percent were of "limited suitability;" and 57 percent were "unsuitable." The most suitable materials seem to be uncemented silty or clayey sandstones that lie reasonably close to the surface (0 to 50 feet). Materials comprising the limited suitability class are primarily soft silty or sandy shales and uncemented siltstones and sandstones. Unsuitable materials are composed mainly of cemented sandstones and siltstones and carbonaceous shales.

Although the consolidated bedrock in the White Tail Butte Study Area should break down readily upon weathering, it is generally unsuited for use as plant media at or near the surface in reconstructed profiles. The bedrock may be highly saline, slowly permeable, clayey, and/or erosive. These soil-related deficiencies would increase the hazard to new seedlings from erosion and the

reduced availability of soil moisture. Other adverse effects of placing bedrock materials on the surface could be a reduced vegetative cover and an increased contribution of sediment to receiving streams.

SOIL INVENTORY

This section was incorporated into the main report in order to provide additional data on the soils occurring in the White Tail Butte Study Area. Much of the information presented was taken from soil survey data compiled by the Soil Conservation Service (U.S.D.A.).

The following data are included in the main report:

1. A soils map of the study area showing the soil series/associations mapped by the Soil Conservation Service.

2. Interpretive ratings for selected soil uses.

3. Soil profile descriptions and erosion evaluations.

4. Descriptions of the Soil Conservation Service mapping units delineated on the soils map.

MOISTURE RELATIONS IN SOILS

The White Tail Butte Study Area is traversed by an east-west trending relict surface with the land sloping away to the north and south. Slope gradients can be used to separate colluvium from residuum and alluvium. Colluvium is associated with slopes exceeding 10^{o}, whereas residuum and alluvium are associated with slopes ranging from 1 to 8^{o}.

Grasses predominate over shrubs in areas with residual soils because drainage is impeded by bedrock. Shrubs predominate over grass on alluvium, because the alluvium is well drained. As a result, more force must be exerted to obtain water than when water is stored in thicker films. Bedrock also impedes drainage beneath colluvium and areas covered by thin baked rock (clinker). This results in a cover of grass rather than shrubs. Grasses predominate in swales or other low areas having good drainage, because larger quantities of water are stored in those soils. The extra water is derived from upstream runoff or from snow blown in from higher areas.

The alluvial soil materials have the most optimum moisture-retention characteristics of the several materials available for revegetation.

GREENHOUSE

The objective of the greenhouse study was to evaluate the suitability of overburden (soil and bedrock) materials in the White Tail Butte Study Area for use as plant growth media.

Western wheatgrass was chosen as the test species because it is one of the most abundant native species in the western United States and will probably be used in many revegetation programs.

Relative yields were calculated as a percentage yield of a standard soil (Platner) and were rated as follows: 0-33 percent - low; 34-67 percent - medium; and above 67 percent - high.

Relative yields for 10 percent of the bedrock samples were low, 44 percent were medium, and 46 percent were high. However, many of the samples which produced medium and high yields may not be suitable for use as plant media under field conditions due to their fine texture (clay-rich), infertility, or salinity/sodicity problems.

Soil samples from the study area generally yielded less than the bedrock samples. Relative yields for 12 percent of these samples were low, 66 percent were medium, and 22 percent were high. Under actual field conditions, the soil materials will probably be more suitable for use as plant media than the bedrock materials due to more favorable physical and chemical properties.

VEGETATION

Topographic variation (slopes and exposures) and a variety of soil parent materials in the area provide habitats for a number of contrasting plant communities. These include grasslands, shrublands, and a tree type. Vegetation types sampled include: (1) silver sagebrush-green needlegrass, (2) bluebunch wheatgrass, (3) blue grama-big sagebrush, (4) western wheatgrass-blue grama, (5) big sagebrush-western wheatgrass, (6) bluebunch wheatgrass-big sagebrush, (7) big sagebrush-bluebunch wheatgrass, and (8) ponderosa pine-little bluestem.

Most of the vegetation types were considered to be in good to excellent range condition; some were in fair to good condition. Yields for the different types were 446 lbs/acre for the least productive (bluebunch wheatgrass-big sagebrush) and 1,380 lbs/acre for the most productive (silver sagebrush-green needlegrass). Carrying capacities ranged from 1.4 acres per animal unit month for the silver sagebrush-green needlegrass type to 6.2 acres for the big sagebrush-western wheatgrass type.

HYDROLOGY

SURFACE WATER

Two small basins, North Divide Draw and Elk Creek tributary, were used for samples to study surface-water hydrology of the White Tail Butte Area. The two basins are similar in size and topography but different in areal extent and the distribution of exposed clinker.

Total annual runoff from North Divide Draw and Elk Creek Tributary was 61.0 acre-ft and 19.2 acre-ft, respectively. Runoff from snowmelt produced about 5 percent of the annual runoff from a snowpack which contained about 240 acre-ft of water. The remainder of runoff was produced by high-intensity convective storms. Rainfall-runoff models were calibrated for the two basins using rainfall and runoff data collected during the summers of 1976 and 1977. Model parameters defined by the calibration process were used with long-term precipitation and evaporation records to simulate 73 years of peak discharge and volume data. The long-term data, collected at Cheyenne, were adjusted to represent the climate of the White Tail Butte area.

Log-Pearson Type III probability distribution was applied to the 73 years of simulated data to define the magnitude versus frequency-runoff curves for the two basins. Results of the study show that an increase in area of exposed clinker reduces runoff.

The runoff estimated by the use of the rainfall-runoff model for North Divide Draw is 19 to 33 percent greater than that estimated from equations based on basin characteristics. Runoff estimated for Elk Creek tributary is 80 to 88 percent less.

Impacts of surface mining on runoff could not be evaluated, but sensitivity of runoff to infiltration was investigated. The study shows that for a 1-percent change in infiltration, runoff changes inversely by about 10 percent.

SEDIMENT YIELDS

Estimated sediment yields from source areas are variable owing to differences in surficial materials and relief, and the associated amount of vegetation cover. Low annual sediment yields (0 to 0.35 acre-ft/mi^2) occur from bottomland alluvium, mesas and clinker-mantled rolling plains, all of which have good to excellent vegetation cover. High sediment yields (1.4 to 2.3 acre-ft/mi^2) occur from steep, dissected, relatively barren hillslopes underlain by erosive sedimentary rocks. Channel erosion by headcutting appears to be significant in some of the draws in those areas. Moderate sediment yields (0.36 to 0.75 acre-ft/mi^2) occur from hill-and-valley areas with a mixture of two or more of the above-mentioned surficial materials. Those areas have more vegetation and are less dissected than the high-yielding areas. Estimated sediment discharges from small drainage basins, 0.28 to 2.13 mi^2 in size, range from 0.04 to 1.53 acre-ft/mi^2. The variations are caused by differences in sediment production from source areas within the basins and differences in sediment transport efficiencies of the main channel systems.

During mining and reclamation there is potential for improving the vegetation and reducing the sediment yield from the high-yielding areas by reducing the slope gradients and increasing the thickness of soil material. To do this would involve mining of the coal underlying the Elk Creek and/or White Tail Creek valley floors and moving some overburden from the divide between these valleys to fill the void left by removal of the coal. This reduction in slope gradients plus the application of land treatments to increase infiltration and seeding of adapted native grasses on the mined area should result in low to moderate sediment yields for most of the area following a stabilization period of perhaps 10 years.

HYDROLOGIC CLASSIFICATION OF LAND TYPES USING RAINFALL SIMULATION

Simulated rainfall at an intensity of about 2 in/hr was applied to four very small watersheds, 2,000 to 3,000 ft^2 in area. Runoff and sediment yield were very low from a moderately steep, well-grassed watershed underlain by baked rock (clinker). Runoff was moderate, but sediment yield was low from a watershed in an upland swale that was well grassed. An area with fine-textured soil and about 66 percent cover of sagebrush and grass produced high runoff, but

sediment yield was fairly low. Runoff was high and sediment yield was moderate from an eroding area that had about 51 percent cover of grass and sagebrush.

GROUND WATER

Work in Campbell County has resulted in a conceptual model of ground water movement in the aquifers more than 1,000 feet deep and for movement in the Wyodak coal. Movement in the deeper aquifers is northward in the northern part of Campbell County, as determined from a potentiometric map of deep wells open to one or more of the Tullock Member of the Fort Union Formation, the Lance Formation, and the Fox Hills Sandstone. It is not definitely known if the water levels in the deep wells represent the same potentiometric surface, but the contours agree with a potentiometric map for the Fox Hills-Lance aquifer to the north in Montana (W. R. Miller, oral commun. 1978). The results of the study in the White Tail Butte area are consistent with the regional model of movement in the deeper aquifers because heads increase with depth in the Tullock Member of the Fort Union Formation north of Weston, Wyoming.

The potentiometric surface in the Wyodak coal, which is equivalent to the Anderson and Canyon coal of the White Tail Butte area, indicates there is recharge at the coal outcrop from the southern part of Campbell County as far north as T. 46 N. and that the coal outcrop near Gillette is a discharge point. The water levels in piezometers completed in the Anderson and Canyon coals in the White Tail Butte area are higher than nearby outcrops of the coals, indicating it is also a discharge area.

Although the White Tail Butte area seems to be a discharge point for part of the regional flow, the amount of water being discharged from the regional system in the area is small compared with water moving locally through the system. Water of a sodium-bicarbonate type with dissolved-solids concentration greater than 1,000 mg/L generally occurs in the aquifers where water has moved through them for distances of a few miles. However, neither the water sampled from springs nor that sampled from alluvium contained this combination of high bicarbonate and dissolved solids. This indicates that the water had not moved a great distance through the bedrock aquifers.

If surface mining occurs, hillside springs will be destroyed in the mined area and will not be restored unless special reclamation procedures are used. However, aquifers occur below the coal so there is enough water of suitable quality to reclaim the land for livestock grazing, which is the present land use.

WILDLIFE

The study area falls within the Upper Missouri River and Broken Lands physiographic region and the wheatgrass-needlegrass (Agropyron-Stipa) vegetation type as described by Kuchler (1964). Major plant species present include big sagebrush (Artemisia tridentata), bluebunch wheatgrass (Agropyron spicatum), western wheatgrass (Agropyron smithii), blue grama (Bouteloua gracilis), and threadleaf sedge (Carex filifolia). Numerous other grass, forb, and shrub species occur with lesser frequency.

Wildlife associated with this area consists primarily of pronghorn antelope, mule deer, and sage grouse. Other characteristic species include the desert cottontail, horned lark, Brewer's sparrow, western meadowlark, wintering golden eagle, and rough legged and ferruginous hawks.

The only specific unique habitat is a six-acre livestock reservoir in T. 56 N., R. 73 W., Section 26, SE¼SE¼, that contains a stocked population of 12- to 14-inch rainbow trout.

CULTURAL RESOURCES

The evidence of prehistoric occupation of the study area identified during an inventory conducted in 1976 consisted of five sites, and four isolated tools or stone flakes. Remains of two individual bison with no cultural association were also observed. None of the identified cultural values is eligible for nomination to the National Register of Historic Places, and no additional archeological work is needed.

Two of the sites identified consisted of individual tipi rings: one on top of White Tail Butte, and one on a bench at its west end. Both tipi rings were constructed of large scoria fragments ranging in diameter from 30 to 50 centimeters. The tipi rings themselves are 2.5 meters in diameter. The other three sites consisted of small lithic scatters located on small benches around White Tail Butte. Since no diagnostic artifacts were located during the inventory, the occupation of the study area cannot be dated.

Ninety percent of the lithic materials located on the five sites consisted of porcelanite and fused glass material which is a distinctive lithic material of coal burn areas and occurs naturally in the scoria or baked shale on White Tail Butte. The use of porcelanite as a tool stone has been dated throughout the past 8,000 years in the Powder River Basin.

The two isolated bison remains were located in two head cuts, 6.6 feet below the surface. These remains lacked any cultural affiliation; however, they do indicate that other cultural remains may be deeply buried in the valley bottoms around White Tail Butte.

RECREATION AND VISUAL MANAGEMENT

The study area is within a relatively high value deer and antelope hunting area. There is some limited fishing opportunity in the stocked livestock reservoir. Because of the distance from perennial streams and settled areas, other recreational use is limited.

Public access to the area is provided by a county road that passes through the site.

A visual resource management survey of the area resulted in a classification of IV. This indicates an area of relatively low visual resource value. It is an area where man's activities will not detract from the aesthetics.

RECOMMENDATIONS FOR RECLAMATION

Special consideration should be given to the following factors when developing a reclamation plan for the White Tail Butte Study Area: (1) stability of the postmining landscape, (2) restoration of water resources, (3) erosion control, and (4) revegetation.

STABILITY OF THE POSTMINING LANDSCAPE 1/

The design of stable postmining landscapes will require the integration of several critical factors: These include: (1) a detailed knowledge of the distribution of overburden materials, with emphasis on the delineation of highly sodic spoils, (2) proper equipment selection, and (3) a consideration of seasonal factors. For reclamation to be successful, consideration must be given to the entire landscape, not merely the soil zone.

Three forms of landscape instability are common on reclaimed coal-mined areas in the Northern Great Plains. These are area-wide settling, local collapse, and piping.

Area-wide settling is common in most postmining landscapes, but appears to cause only minimal disruption. This form of subsidence will generally be most pronounced during the first year following reclamation and will continue at a decreasing rate for a number of years. The two major factors influencing area-wide settling are: (1) texture of the overburden, and (2) equipment used in spoil contouring operations.

Fine-textured overburden usually results in more blocky and, initially, more porous spoils than does coarse-textured overburden. Therefore, a lesser degree of area-wide settling can be expected in areas of largely sandy spoils than in areas of largely clayey spoils.

Equipment used in contouring operations is a critical factor influencing area-wide settling. Settlement is significantly less in scraper-contoured areas than in dozer-contoured areas due to the fact that scrapers more effectively break down large overburden blocks and compact the spoil mass. Therefore, the degree of area-wide settlement may be reduced by employing scrapers rather than dozers in spoil contouring operations.

Local large-scale collapse often develops soon after contouring is completed. Development typically ends within one year. This form of instability is predominant in precontouring valleys where large, frozen spoil blocks are concentrated by mid-winter dozer contouring. Thawing of these blocks results in local surface subsidence. To restrict the development of local collapse features, the use of scrapers rather than dozers should be considered for contouring operations during the winter months.

1/Groenwold, G.H. and Rehm, B.W., 1980.

Piping appears to be a severe and long-term problem in some postmining landscapes. This form of instability usually begins soon after contouring ceases and may continue for several years. In some postmining landscapes, piping has only started to develop after as much as five years.

Piping is apparently controlled by a combination of physical and chemical conditions in the spoils. All piping begins as a crack, either on the surface of exposed spoils or at the topsoil-spoil interface. In the latter case, the overlying topsoil collapses into the pipe and is carried away. Repeated topsoil application is usually unsuccessful in stopping the growth and development of piping. Cracking of spoils is restricted to areas of highly dispersive sodic materials. The cracks allow access for large volumes of surface runoff to flow into the subsurface of the spoils. However, surface cracking alone will not necessarily result in the development of piping. Piping will develop only if an avenue for water movement can result from fracturing within the mass of spoils due to differential settling between differentially compacted areas (i.e., scraper-contoured area adjacent to dozer-contoured area) or within areas of poorly compacted spoils (i.e., dozer contouring only).

Piping usually develops in nearly flat areas, where runoff is minimal and infiltration is maximized. Thus, the final surface slopes in reclaimed areas must also be recognized as controlling factors in the development of piping.

Given the proper conditions of slope, near-surface dispersive materials, and a permeable zone in the base of the spoils, piping may continue to develop and disrupt postmining landscapes for many years. Selective handling of highly sodic overburden may prove to be the only effective means of controlling piping in many areas in the Northern Great Plains.

Because postmining landscapes tend to be unstable, structures should not be built on reclaimed lands unless they are specifically designed to absorb differential settlement. Also, reconstructed drainage channels will require periodic maintenance to ensure that ponded areas to not develop in areas of localized settlement.

RESTORATION OF WATER RESOURCES

Surface Water

The overall objective for surface water in the reclamation plan should be to restore the pre-mining hydrologic function of the site. However, there are opportunities during the reclamation phase to improve upon the pre-mining surface water resource, particularly from a runoff timing standpoint.

Rapid establishment of a grass cover on critical watershed slopes and channel areas is the first prerequisite in achieving a stable watershed. Channel areas should be seeded to sod-forming grasses to achieve grass-lined waterways. Transplanting native sod to these waterways should be considered.

The objective in channel reconstruction should be to decrease channel gradients and increase width/depth ratios so that flow velocities are decreased. The storage capacity of the replaced "alluvium" in channel areas should be duplicated or increased over pre-mining conditions to insure adequate base flows. The material used to replace the alluvium should have approximately the same (or better) geochemical properties. The channel reconstruction and alluvium replacement will facilitate rehabilitation of the riparian and woody draw ecosystems that are found in the study area.

Contour furrowing, gouging, or similar land treatments should be applied to the steeper reclaimed slopes to promote infiltration, increase retention storage, and decrease flood volumes.

If stock and wildlife water impoundments are included in the lease stipulations, these structures should be designed so as to also function as runoff control structures.

Runoff from the study area is currently supplying water for stock ponds and flood irrigation below the study area. Provisions for maintaining these water supplies, both quantity and quality, should be included in the lease stipulations. No large water retention structures should be built above the existing structures.

Ground Water

It can generally be assumed that aquifers located above the deepest coal seam to be mined will be destroyed. Also, springs and seeps will probably not occur on hillsides in the reclaimed area because the replaced overburden will not have the relatively continuous bedding of the original sedimentary deposits. Aquifers that lie below the mined area will not be disturbed. Those that lie outside the mined area, and are lateral equivalents of disturbed aquifers, should also not be greatly affected.

Ground water recharge capacity in the reclaimed area will depend on such factors as: (1) postmining topography, (2) properties of the overburden materials, and (3) the moisture conservation techniques employed.

If surface mining occurs in this study area, the existing topography will probably be reshaped to a more gently sloping condition. This would allow a greater percentage of infiltration in the reclaimed area. Therefore, the rate of recharge to deep aquifers would be increased. However, this increase would be difficult to quantify.

The properties of the overburden materials are important factors influencing recharge capacity. The fractured state of the spoils initially will allow for increased recharge of deep aquifers as water percolates freely downward under gravitational force. However, as weathering and subsidence of spoils occur, impermeable layers may develop which will limit the rate of recharge to deep aquifers. In local areas, "perched" aquifers could develop above these impermeable strata.

Implementation of such moisture conservation techniques as contour furrowing, gouging, pitting, etc., may also influence the amount of ground water recharge. The objective of these techniques is to reduce runoff and maximize infiltration. If one or more of these measures is employed on reclaimed land in this study area, recharge capacity should be improved due to the increase in infiltration.

The ground water supply that will be available in the reclaimed area is difficult to estimate. To obtain suitable stock and domestic water supplies, it may be advantageous to drill one main well to a deep aquifer and distribute the supplies through a pipeline system to selected locations. From an economic standpoint, this technique appears more desirable than drilling a number of deep, expensive wells.

EROSION CONTROL

One or more of the following conservation practices may be employed on reclaimed land in the White Tail Butte Study Area to control erosion and minimize sediment loading to receiving streams: (1) reducing the mean surface slope of the area, (2) lining reconstructed drainage channels, (3) gouging, (4) pitting, (5) terracing, (6) contour furrowing, (7) mulching, and (8) establishing a permanent vegetative cover on topsoiled areas as quickly as possible.

If surface mining occurs in this study area, reshaping the postmining topography to a more gently rolling condition should be considered. By reducing the mean surface slope in the reclaimed area, the potential for runoff and erosion would be reduced. Also, the quantity of soil moisture available for plant use would be increased due to an increase in infiltration.

To minimize the potential for gully erosion and severe soil losses, reconstructed stream channels should be lined with a durable rip-rap material or a vegetative cover of adapted plant species. If possible, riparian vegetation in the study area should be removed prior to mining and replaced in the reconstructed drainages. Another technique which could be employed to retard gully erosion in reconstructed drainages would be to widen the stream channels. This would cause flows to be shallower and less erosive.

On slopes exceeding 5 percent in the reclaimed area, it is strongly recommended that closely-spaced contour furrowing, gouging, pitting or terracing be employed to minimize erosion and reduce sediment yields. These practices are very effective in capturing precipitation that might otherwise be lost in runoff. Thus, runoff and erosion are reduced, while the amount of soil moisture available for seed germination and plant development is increased.

To comply with Wyoming law, mulch or other suitable soil stabilizers (i.e., chemical binders) must be applied to all topsoiled areas in order to conserve soil moisture and control erosion. If straw or hay mulch is applied, it should be disked or "crimped" (cutaway roller disk) into the soil surface to prevent substantial losses of the material due to blowing.

Annual grains or grasses may be substituted for, or used in conjunction with, another mulch if the Wyoming Department of Environmental Quality determines that they will provide adequate erosion control and will be later replaced by perennial species approved for the postmining land use. Recent investigations in Wyoming have shown that standing stubble (in situ mulch) from spring planted small grains is slightly more effective in controlling erosion on topsoiled areas than crimped straw.[2/] Furthermore, areas protected by standing stubble show higher infiltration rates and lower diurnal fluctuations in soil temperature - both factors being very important to seed germination and plant growth. Based on this data, and the fact that the cost of providing standing stubble is substantially less (75 to 95 percent) than using crimped straw, the use of stubble as an alternative mulch should be considered for reclaimed lands in the White Tail Butte Study Area.

Probably the most effective method of controlling erosion on topsoiled areas is establishing a permanent vegetative cover as quickly as possible. If a permanent cover can not be established within 45 days, a temporary cover of small grains, grasses, or legumes should be established.

REVEGETATION

Revegetation of surface-mined land in the White Tail Butte Study area will require: (1) removal, segregation, and redistribution of suitable plant growth material, (2) proper grading of area surfaces, (3) selection of adapted plant species, (4) use of proper planting and seedbed preparation procedures, (5) application of fertilizer and/or soil amendments, and (6) management of the reclaimed area until vegetation has become permanently established.

Removal, Segregation, and Redistribution of Suitable Plant Growth Material

Prior to the actual mining operation, all suitable plant growth material should be removed and segregated in separate stockpiles. Surface soil, because of its natural fertility, higher organic matter content, and stable structure, is usually the most suitable material available. However, this is not always the case. Surface soils on some lands may be clay-rich, slowly permeable, saline/sodic, and/or erosive. If the existing surface soil is determined to be unsuitable for revegetative purposes or is lacking in quantity, subsoil material may be utilized as a substitute for, or in addition to, the topsoil if approved by the regulatory authority (Wyoming Department of Environmental Quality - DEQ).

Topsoil or substitute revegetative material should be stockpiled separately following its removal unless it is to be redistributed immediately on regraded areas. Selective placement of the stockpiles will be necessary to protect the topsoil from contamination by toxic spoils. In order to minimize erosion, a quick-growing vegetative cover should be established on the stockpiles.

2/Schuman, G.E., Taylor, E.M., et al, 1980.

After final grading (of spoils) and before the suitable plant growth material is respread, regraded land should be scarified or otherwise treated to eliminate slipppage surfaces and enhance root penetration. The redistribution of plant growth material should then proceed in a manner that: (1) achieves an approximate uniform thickness consistent with the planned postmining land use, (2) prevents excess compaction of the plant media, and (3) protects the plant growth material from wind and water erosion before sufficient vegetation is established.

Grading of Area Surfaces

Wyoming law presently requires that: "All overburden, spoil material, and refuse piles must be designed, graded, and contoured so as to blend in with the topography of the surrounding terrain (slope requirements will depend on an average of the slopes of the surrounding area and on the nature of the material) . . . . The slopes of all spoil areas must be designed so that they will be stabilized against wind and water erosion. This may include terracing, channeling around the toe of the spoil piles, or other techniques." Furthermore, "Contouring of spoil piles must provide for drainage patterns that complement the surrounding terrain and provide for long-term stability."

Where possible, all final grading, preparation of regraded land before redistribution of topsoil, and placement of suitable surfacing material should be done along the contour to minimize erosion and increase stability.

Selection of Adapted Plants

Plant species and seeding rates proposed for revegetation are subject to approval by DEQ. Seed types will depend on the climatic and soil conditions prevailing in the area to be revegetated and the proposed postmining land use(s). Species to be established as permanent cover should be self-renewing. Seeding rates will depend on seed type, climatic and soil conditions, and techniques to be used in seeding.

Introduced species may be substituted for native species if revegetation test plots show such species to be of equal or superior utility for reclamation purposes. The use of introduced species is subject to approval by DEQ.

Plant selection for revegetation is very important. Some considerations in selecting revegetative species for the White Tail Butte Study Area should include: drought resistance, salt and sodium tolerance, resistance to winterkill, palatability, and resistance to grazing pressure. Of equal importance is plant compatibility with soil type, slope, aspect, and drainage conditions.

The following seeding rates and mixtures are suggested for revegetation on: 1) loamy and clayey soils, and 2) sandy soils in the White Tail Butte Study Area 3/:

3/ This data was obtained from the Soil Conservation Service, U.S. Department of Agriculture, Gillette, Wyoming.

Loamy - Clayey Soils

Green Needlegrass	3 lbs/acre
Rosanna western wheatgrass	3 lbs/acre
Critana thickspike wheatgrass	3 lbs/acre
Fourwing saltbush	1 lb/acre

Sandy Soils

Goshen Prairie sandreed	3 lbs/acre
Indian ricegrass	3 lbs/acre
Critana thickspike wheatgrass	3 lbs/acre
Fourwing saltbush	1 lb/acre

Alternate plants native to the Upland - Sagebrush, Ponderosa Pine, and Riparian (natural drainages) plant communities found in this area which may also be considered for revegetation include:

Upland - Sagebrush Plant Community

Big sagebrush	Skunkbush sumac
Fourwing saltbush	Winterfat
Western wheatgrass	Green needlegrass
Indian ricegrass	Thickspike wheatgrass
Bluebunch wheatgrass	Prairie junegrass
Scarlet globemallow	Purple prairieclover
Prairie coneflower	

Silver sagebrush
Little bluestem
Sand dropseed

Sandy areas

Ponderosa Pine Plant Community

Ponderosa Pine	Skunkbush sumac
Juniper	Big sagebrush
Bitterbrush	Bluebunch wheatgrass
Mutton bluegrass	

Riparian (Natural Drainages) Plant Community

Wood's rose	Currant
Buffaloberry	Streambank wheatgrass
Prairie cordgrass	Western wheatgrass
Saltgrass	Cottonwood
Willow	

Seeding/planting rates and mixtures should be selected on the basis of specific site conditions (i.e. - soil type, slope, aspect, drainage conditions, etc.).

Planting and Seedbed Preparation

Topsoiled areas which have been severely compacted by heavy machinery should be ripped 18 to 24 inches before preparing the seedbed. Disking should then be conducted prior to seeding and/or planting. With proper seedbed preparation, successful germination and establishment of revegetative species will be enhanced.

Seeding and/or planting should be conducted during the first normal period for favorable planting conditions after suitable plant growth material has been spread. The normal period for favorable planting is that planting time accepted locally for the plant species selected to meet specific site conditions and climate.

Mechanical drill seeding is generally the preferred technique, but good stands may also be established by broadcasting or hydroseeding. If drill seeding is the selected method, it should be conducted on the contour to minimize erosion and increase the potential for moisture retention. In order to provide favorable growing conditions, seeds should be covered by about one-half inch of soil.

Application of Fertilizer and Soil Amendments

In order to support the planned postmining land use(s) and meet all revegetation requirements, nutrients (fertilizer) and/or soil amendments should be applied to the redistributed surface soil layer in the amounts determined by soil tests.

All soil tests should be performed by a qualified laboratory using standard methods approved by the regulatory authority (DEQ).

Management of the Revegetated Area

In Wyoming, the coal mine operator is responsible for management of the reclaimed area until such time as: (1) the vegetative cover on the disturbed area is capable of renewing itself under natural conditions prevailing at the site, and is at least equal to the cover on the area before mining, (2) the productivity is at least equal to the productivity of the area before mining, (3) the species diversity and composition are suitable for the land use goal, and (4) the requirements of (1), (2), and (3) are met for 2 consecutive years.

Assuming that range will be the primary postmining land use, young vegetative growth should be protected from livestock grazing by fencing or other techniques until the vegetation is capable of withstanding grazing pressure at least comparable to that which existed prior to mining.

REFERENCES

1. Groenwold, G.H. and B.W. Rehm, 1980, Instability of Contoured Surface-Mined Landscapes in the Northern Great Plains: Causes and Implications, 15 pp.

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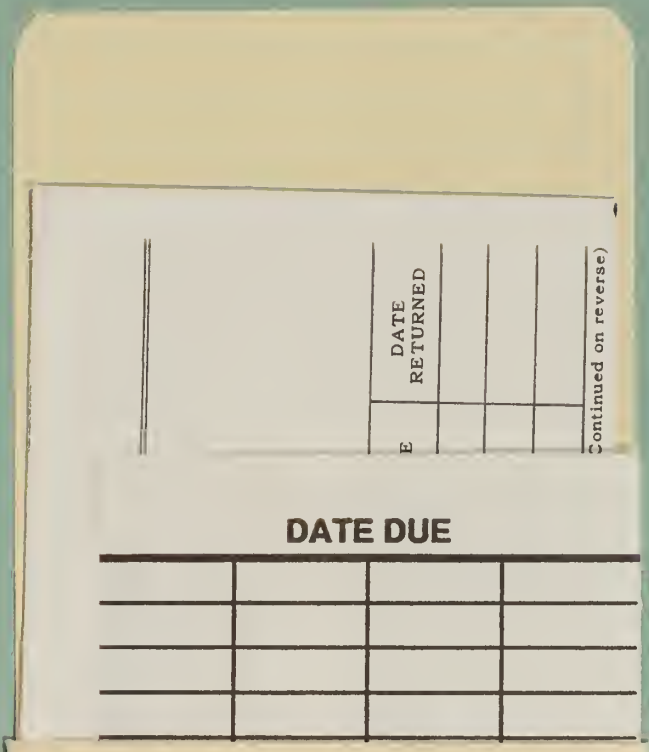

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